Patent Claims

1. A method for producing a buried tunnel junction (1) in a surface-emitting semi-conductor laser having an active zone (5) with a pn-junction surrounded by a first n-doped semi-conductor layer (6) and at least one p-doped semi-conductor layer (3, 4) and having a tunnel junction (1) on the p-side of the active zone (5), which borders on a second n-doped semi-conductor layer (2), wherein the layer destined for the tunnel junction (1) is laterally ablated in a first step by means of material-selective etching up to a desired diameter of the tunnel junction (1) and in a second step is heated in a suitable atmosphere, until the etched gap is closed by mass transport from at least one semi-conductor layer (2, 3) bordering on the tunnel junction (1).

2. The method according to Claim 1, wherein at least one of the semi-conductor layers (2, 3) bordering on the tunnel junction (1) consists of a phosphide compound, preferably consisting of InP.

3. The method according to Claim 1 or 2, wherein as atmosphere in the said second step a phosphoric atmosphere, preferably PH_3 and hydrogen, is used.

4. The method according to one of Claims 1 to 3, wherein the temperature in the said second step is chosen to be between 500 and 800 °C , preferably between 500 and 600 °C.

5. The method according to one of Claims 1 to 4, wherein, starting with an epitaxial initial structure of the surface-emitting semi-conductor laser, in which a p-doped semi-conductor layer (3), the layer destined for the tunnel junction (1), and the second n-doped semi-conductor layer (2) are applied sequentially on the p-side of the active zone (5), using photolithography and / or etching a circular or ellipsoid stamp is formed, whose flanks encompass the second n-doped semi-conductor layer (2) and the layer destined for the tunnel junction (1) and extend at least to underneath the layer destined for the tunnel junction (1), and, subsequently, said first and said second step are embodied for producing the buried tunnel junction (1).

6. The method according to one of Claims 1 to 5, wherein an additional semi-conductor layer (21) adjoins the second n-doped semi-conductor layer (2) at the p-side of the active zone (5), said semi-conductor layer (21) in turn borders on a third n-doped semi-conductor layer (2'), whereby this additional semi-conductor layer (21) is laterally ablated up to a desired diameter by means of material-selective etching and then is heated in a suitable atmosphere until the etched gap is closed by mass transport from at least one of the semi-conductor layers (2, 2') bordering on the additonal semi-conductor layer (21).

7. The method according to Claim 6, wherein different semi-conductors are used for the additional semi-conductor layer (21) and for the tunnel junction (1).

8. The method according to Claim 7, wherein InGaAsP is used for the additional semi-conductor layer (21) and InGaAs is used for the tunnel junction (1).

9. The method according to one of Claims 6 to 8, wherein the additional semi-conductor layer (21) is arranged in a maximum of the longitudinal electrical field, while the tunnel junction (1) is in a minimum of the longitudinal electrical field.

10. The method according to one of Claims 1 to 9, wherein for the material-selective etching $H_2SO_4 : H_2O_2 : H_2O$ is used as the etching solution in a ratio of 3:1:1 to 3:1:20, if the tunnel junction (1) is comprised of InGaAs, InGaAsP or InGaAlAs.

11. A surface-emitting semi-conductor laser having an active zone (5) with a pn-junction surrounded by a first n-doped semi-conductor layer (6) and at least one p-doped semi-conductor layer (3, 4), and a tunnel junction (1) on the p-side of the active zone (5), which borders on a second n-doped semi-conductor layer (2), wherein the tunnel junction (1) is laterally embraced by a zone (1a), which connects the second n-doped semi-conductor layer (2) with one of the p-doped semi-conductor layers (3, 4) and which is formed from at least one of these adjacent layers (2, 3) by mass transport.

12. A surface-emitting semi-conductor laser according to Claim 11, wherein at least one of the semi-conductor layers

(2, 3) bordering on the tunnel junction (1) consists of a phosphide compound, preferably consisting of InP.

13. A surface-emitting semi-conductor laser according to Claim 11 or 12, characterized in that a p-doped InAlAs layer (4) as the at least one p-doped semi-conductor layer followed by a p-doped InP layer (3) abuts with the active zone (5).

14. The surface-emitting semi-conductor laser according to one of Claims 11 to 13, wherein the tunnel junction (1) is arranged in a minimum of the longitudinal electrical field.

15. The surface-emitting semi-conductor laser according to one of Claims 11 to 14, wherein an additional n-doped semi-conductor layer (6a) is present between the active zone (5) and the first semi-conductor layer (6), which is configured as a semi-conductor mirror.

16. The surface-emitting semi-conductor laser according to one of Claims 11 to 15, wherein an additional semi-conductor layer (21) is present, which abuts on the second n-doped semi-conductor layer (2) bordering on the tunnel junction (1) and which itself borders on a third n-doped semiconductor layer (2'), whereby this additional semi-conductor layer (21) is laterally surrounded by a zone (20), that connects the second n-doped semi-conductor layer (2) with the third n-doped semi-conductor layer (2') and is generated by mass transport from at least one of these two layers (2, 2').

17. The surface-emitting semi-conductor laser according to Claim 16, wherein the refractive index of the additional

semi-conductor layer (21) differs from the one or those of the two surrounding layers (2, 2').

18. A surface emitting semi-conductor laser according to Claim 16 or 17, wherein the additional semi-conductor layer (21) is arranged in a maximum of the longitudinal electrical field.

19. The surface emitting semi-conductor laser according to one of Claims 16 to 18, wherein the additional semi-conductor layer (21) and the tunnel junction (1) are comprised of different semi-conductor materials.

20. The surface-emitting semi-conductor laser according to Claim 19, wherein the additional semi-conductor layer (21) is comprised of InGaAsP and the tunnel junction (1) of InGaAs.

21. The surface-emitting semi-conductor laser according to one of Claims 16 to 20, wherein the diameter of the additional semi-conductor layer (21) is greater than that of the tunnel junction (1).

22. The surface-emitting semi-conductor laser according to one of Claims 16 to 21, wherein the band gap of the additional semi-conductor layer (21) is greater than the band gap of the activation zone (5).